WHAT IS CLAIMED IS:

1. A nano-structure of oxide or complex oxide of a metal element,

wherein the metal element is at least one selected from the group consisting of transition metal elements, group IA elements, group IIA elements, group IIIB elements, group IVB elements, group VB elements and group VIB elements and has an ability to compose a fluoride complex ion, and

wherein a stability constant of the metal fluoride complex is smaller than that of aluminum fluoride.

2. A stacked nano-structure of oxide made from the first oxide or complex oxide of a metal element and the second oxide or complex oxide of a metal element,

wherein the metal element is at least one selected from the group consisting of transition metal elements, group IA elements, group IIA elements, group IIIB elements, group IVB elements, group VB elements and group VIB elements and has an ability to compose a fluoride complex ion, and

wherein a stability constant of the metal fluoride complex is smaller than that of aluminum fluoride.

3. The nano-structure according to claim 1 or 2, wherein the oxide or complex oxide comprises fine particles

of metal.

4. The nano-hole array according to any one of claims 1 to 3, wherein aluminum oxide remains in an amount of 0.1 volume% or more, relative to the total oxide.

5. A nano-structure which is made by nitriding, reducing, and carbonizing the nano-structure of oxide according to claim 1 or 2.

6. The nano-structure according to any one of claims 1 to 5, which is a nano-hole array wherein nano-holes which have penetrating pores of 50 μm or more, are arranged like a bundle.

7. The nano-structure according to claim 6, wherein the aspect ratio is 100 or more.

8. The nano-structure according to any one of claims 1 to 5, which is a nano-hole array with a substrate, wherein the nano-holes are arranged like a bundle on at least one main surface of the substrate.

9. The nano-structure according to claim 8, wherein the length of the nano-hole is 1 μm or more.

10. The nano-structure according to claim 8, wherein the aspect ratio is 5 or more.

11. The nano-structure according to claim 8, wherein the substrate is electrically conductive metal or non-metal.

12. The nano-structure according to any one of claims 1 to 5, which is a nano-rod of oxide.

13. The nano-structure according to claim 12, wherein the length of the nano-rod is 1 μm or more.

14. The nano-structure according to claim 12, wherein the aspect ratio is 5 or more.

15. The nano-structure according to any one of claims 1 to 5, which is a nano-needle of oxide.

16. The nano-structure according to claim 15, wherein the length of the nano-hole is 1 μm or more.

17. The nano-structure according to claim 15, wherein the aspect ratio is 5 or more.

18. The nano-structure according to claim 15, wherein the inside diameter is 10 to 500 nm.

19. A method of preparing a nano-structure of oxide, which comprises:

a step of preparing a template which has a nano-structure and is made from oxide;

a step of preparing a solution which contains a fluoride complex ion of the metal element of the target oxide; and

a step of immersing the oxide template into the solution to substitute of the oxide template with the target oxide.

20. The method of preparing a nano-structure of oxide according to claim 19,

wherein the target oxide is a metal element which is at least one selected from group consisting of transition metal elements, group IA elements, group IIA elements, group IIIB elements, group IVB elements, group VB elements and group VIB elements and has an ability to compose a fluoride complex ion, and

wherein the stability constant of the fluoride complex is smaller than that of aluminum fluoride.

21. The method of preparing a nano-structure of oxide according to claim 19, wherein the target oxide is the oxide of the metals, fluoride of which is soluble in the water and can be hydrolyzed, and the fluoride complex ion of which is unstable than the aluminum fluoride.

22. The method of preparing a nano-structure of oxide with a substrate according to claim 19, wherein the template is made from oxide and has a layer having nano-structure provided on at least one main surface of the substrate.

23. The method of preparing a nano-structure of oxide with a substrate according to claim 19, wherein the substrate is metal or non-metal.

24. The method of preparing a nano-structure of oxide with a substrate according to claim 19, wherein the template is used which has a layer of aluminum oxide having a nano-structure formed by anodization treatment (anodized alumina) on at least one main surface of an aluminum metal substrate.

25. The method of preparing a nano-structure of oxide according to claim 19, wherein the fluoride complex ion is in an aqueous solution at a concentration of 0.1 mmol/l or more.

26. The method of preparing a nano-structure of oxide according to claim 19, wherein the fluoride complex ion is prepared in which the fluoride complex is present in the form of MF_x^{Y-} (wherein M is a transition metal element, a group IA element, a group IIA element, a group IIIB element, a group IVB element, a group VB element or a group VIB element, x is the number of fluorine atoms and y is an valency).

27. The method of preparing a nano-structure of oxide according to claim 19, wherein the target oxide is formed via a hydroxide which is formed by hydrolysis of the fluoride complex ion in the solution.

28. The method of preparing a nano-structure of oxide according to claim 19, wherein the substitution reaction between the oxide of the template and the target oxide is carried out by a dissolution reaction of the oxide of the template and a precipitation reaction of the target oxide.

29. The method of preparing a nano-structure of oxide according to claim 19, wherein the substitution reaction is carried out in the range of 0 to 80°C under atmospheric pressure.

30. The method of preparing a nano-structure of oxide according to claim 19, wherein the substitution reaction is carried out in the range of 5 to 40°C under atmospheric pressure.

31. The method of preparing a nano-structure of oxide according to claim 19, wherein the substitution reaction comprises at least a first substitution reaction which is conducted in a solution comprising the first fluoride complex ion, and a second substitution reaction which is conducted in a solution comprising the second fluoride complex ion, which reactions are sequentially conducted, to prepare a nano-hole array of oxide wherein at least the first metal oxide and the second metal oxide are stacked.

32. The method of preparing a nano-structure of oxide according to claim 19, wherein the substitution reaction comprises a substitution reaction which is carried out in a solution comprising at least the first fluoride complex ion and the second fluoride complex ion, to prepare a nano-hole array of oxide comprising a complex oxide of at least the first metal oxide and the second metal oxide.

33. The method of preparing a nano-structure of oxide

according to claim 19, wherein the substitution reaction comprises a substitution reaction which is carried out in a solution comprising at least one kind of fluoride complex ion and at least one kind of fine metal particles, to prepare a nano-hole structure of oxide comprising the fine metal particles.

34. The method of preparing a nano-structure of oxide according to claim 19, wherein the substitution reaction is carried out under any of light irradiation, radioactive ray irradiation and ultrasonic irradiation.

35. The method of preparing a nano-structure of oxide according to any one of claims 19 to 34, wherein the template is used which comprises aluminum oxide having a nano-structure formed by anodization treatment (anodized alumina).

36. The method of preparing a nano-structure of oxide according to claim 19 to 34, wherein the template is used which has a structure in which pores are regularly extended on one surface.

37. The method of preparing a nano-structure of oxide according to any one of claims 19 to 34, wherein the

template is used which has a structure in which pores penetrates from one surface to the other surface.

38. The method of preparing a nano-structure of oxide according to any one of claims 19 to 34, wherein the template is used which has a structure having pores of 200 nm diameter on one surface and having pores of 20 nm diameter on the other surface.

39. The method of preparing a nano-structure of oxide according to 19,

wherein the nano-structure is in the form of a nano-rod, and

wherein the substitution process is a reaction of substituting the oxide of the template with the target oxide by making the precipitation reaction rate of the target metal oxide greater than the dissolution reaction rate of anodized alumina.

40. The method of preparing a nano-structure of oxide according to claim 39, wherein the substitution reaction is carried out in the range of 20 to 80°C under atmospheric pressure.

41. The method of preparing a nano-structure of oxide

according to claim 39, wherein the substitution reaction is carried out under addition of a fluoride ion scavenger.

42. The method of preparing a nano-needle of oxide according to claim 19, which comprises a step of separating the nano-hole array of oxide into each of nano-holes of oxide (nano-needles).

43. A high-performance nano-hole array, which is a nano-hole array made from oxide or complex oxide of a metal element,

wherein the metal element is at least one selected from the group consisting of transition metal elements, group IA elements, group IIA elements, group IIIB elements, group IVB elements, group VB elements and group VIB elements and has an ability to compose a fluoride complex ion,

wherein the stability constant of the fluoride complex is smaller than that of aluminum fluoride, and

wherein the penetrating pores of the nano-holes, which have the length of 50 μm or more and the aspect ratio of 100 or more, are arranged like a bundle, or the nano-holes, which have bottoms and have the length of 1 μm or more and the aspect ratio of 5 or more, are arranged like a bundle on at least one main surface of the substrate.

44. The high-performance nano-hole array according to claim 43, responsive to visible light,

wherein the oxide is TiO_2, ZnO, SnO_2, SiO_2 or a mixture thereof, or a complex oxide thereof, and

wherein at least one selected from the group consisting of Ag, Pt and Cu fine particles is dispersed.

45. The nano-hole array according to claim 43 for photochromism, wherein the oxide is TiO_2 or SiO_2, and Ag is supported.

46. The nano-hole array according to claim 43 for an energy-saving photocatalyst, wherein WO_3 is supported in the nano-hole.

47. The nano-hole array according to claim 43 which is used for contacting the electrolyte in a dye sensitization type of a solar cell.

48. The nano-hole array according to claim 43 for a positive electrode of a lithium-ion battery, wherein the oxide is V_2O_5 or TiO_2.

49. The nano-hole array according to claim 43 for a material for thermoelectric conversion, wherein the oxide is

ZnO or TiO.

50. The nano-hole array according to claim 43 for a material for thermoelectric conversion, wherein the oxide is ZnO, TiO_2, SnO_2, Fe_2O_3 or ZrO_2 and the nano-metal is embedded in the nano-hole.

51. The nano-hole array according to claim 43 for a gas sensor wherein the oxide is TiO, TiO_2, ZnO, SnO_2 or a mixture thereof, or a complex oxide thereof.

52. The nano-hole array according to claim 43 for a humidity sensor, wherein the oxide is SnO_2.

53. The nano-hole array according to claim 43 for an odor sensor, wherein the oxide is TiO, TiO_2, ZnO, SnO_2 or a mixture thereof, or a complex oxide thereof.

54. The nano-hole array according to claim 43 for a light sensor or a photonic crystal, wherein the oxide is TiO_2.

55. The nano-hole array according to claim 43 for a filter, wherein the oxide is oxide other than Al_2O_3.

56. The nano-hole array according to claim 43 for a material for CO_2 mobilization, wherein the oxide is represented by a formula MO_b (wherein M is Zr, Fe, Ni, Ti or Si and b is the number of oxygen atoms) or a formula Li_aMO_b (wherein M is Zr, Fe, Ni, Ti or Si, a is the number of lithium atoms, and b is the number of oxygen atoms).

57. The nano-hole array according to claim 43 for high-density memory media, wherein the oxide is a stacked oxide comprising any one of the combinations of Fe_2O_3 and ZrO_2, Fe_2O_3 and TiO_2, Fe_2O_3 and SnO_2, Fe_3O_4 and ZrO_2, Fe_3O_4 and TiO_2, and Fe_3O_4 and SnO_2.

58. A nano-rod, which is separated, respectively, made from oxide or complex oxide of a metal element,

wherein the metal element is at least one selected from the group consisting of transition metal elements, group IA elements, group IIA elements, group IIIB elements, group IVB elements, group VB elements and group VIB elements and has an ability to compose a fluoride complex ion,

wherein the stability constant of the fluoride complex is smaller than that of aluminum fluoride, and

wherein the length of the nano-rod is 1 μm or more and the aspect ratio of the nano-rod is 5 or more.

59. The nano-rod according to claim 58 for a material for matrix reinforcement, wherein the oxide is TiO_2, ZnO, SnO_2, SiO_2 or a mixture thereof, or a complex oxide thereof.

60. The nano-rod according to claim 58 for a photocatalyst, wherein the oxide is TiO_2, ZnO, SnO_2, SiO_2 or a mixture thereof, or a complex oxide thereof.

61. A nano-needle for micro-injection, which is separated, respectively, made from oxide or complex oxide of a metal element,

wherein the metal element is at least one selected from the group consisting of transition metal elements, group IA elements, group IIA elements, group IIIB elements, group IVB elements, group VB elements and group VIB elements and has an ability to compose a fluoride complex ion and the stability constant of the fluoride complex is smaller than that of aluminum fluoride, and

wherein the length of the nano-needle is 1 μm or more and the aspect ratio is 5 or more.

62. The nano-needle for micro-injection according to claim 61, wherein the oxide is ZnO, TiO_2 or SnO_2.

63. The nano-needle for micro-operation according to

claim 61, wherein the oxide is ZnO, TiO_2 or SnO_2.

64. The nano-needle for micro-adhesion according to claim 61, wherein the oxide is ZnO, TiO_2 or SnO_2.